Name Key

Chemical Kinetics Practice Test

1. The balanced equation for the reaction of bromate ion with bromide in acidic solution is given by:

$$BrO_3^- + 5Br^- + 6H^+ \rightarrow 3Br_2 + 3H_2O$$

At a particular instant in time, the value of $-\Delta[Br^-]/\Delta t$ is 2.0×10^{-3} mol/L · s. At what rate is bromine (Br_2) produced in the same units?

a) 1.2×10^{-3}
b) 6.0×10^{-3}
c) 3.3×10^{-3}
d) 3.3×10^{-5}
e) 2.0×10^{-3}

2. Consider the reaction $2H_2 + O_2 \rightarrow 2H_2O$
What is the ratio of the initial rate of the appearance of water to the initial rate of disappearance of oxygen?

a) 1 : 1
b) 2 : 1
c) 1 : 2
d) 2 : 2
e) 3 : 2

3. Consider the reaction $H_2 + NO \rightarrow HNO + H$
Which of the following is a possible rate law?

a) Rate = $k\,[H_2] + [NO]$
b) Rate = $k\,[H_2]\,[NO]$
c) Rate = $k\,[H_2]\,[NO]$ - $[HNO]\,[H]$
d) Rate = $k\,[HNO]\,[H]$
e) Any of these

4. Several reaction mechanisms are proposed for a chemical reaction.
How can the correct mechanism be determined?

a) By process of elimination
b) By conducting experiments to determine the changes in concentration over time.
c) By calculating the bond energies to determine the most exothermic mechanism.
d) By educated guess
e) By creating molecular models to determine which geometries are more stable.

5. A first-order reaction is 40.% complete at the end of 50. s. What is the value of the rate constant (in s^{-1})?

a) 1.8×10^{-2}
b) 1.0×10^{-2}
c) 1.2×10^{-2}
d) 8.0×10^{-3}
e) none of these

$\ln[A] = -kt + \ln[A]_0$

$\ln[.60] = -k(50) + \ln[1]$

$k = 0.0102\ s^{-1}$

6–11. A general reaction written as $1A + 2B \rightarrow C + 2D$ is studied and yields the following data:

Experiment	$[A]_0$ (M)	$[B]_0$ (M)	Initial $\Delta[C]/\Delta t$ (mol/L · s)
1	0.150	0.150	8.00×10^{-3}
2	0.150	0.300	1.60×10^{-2}
3	0.300	0.150	3.20×10^{-2}

6. What is the order of the reaction with respect to B?
   a) 0 b) 1 c) 2 d) 3 e) 4

7. What is the order of the reaction with respect to A?
   a) 0 b) 1 c) 2 d) 3 e) 4

8. What is the overall order of the reaction?
   a) 0 b) 1 c) 2 d) 3 e) 4

9. What is the numerical value of the rate constant?
   a) 0.053
   b) 1.19
   c) 2.37
   d) 5.63
   e) none of these (a-d)

$Rate = K[A]^2[B]$

$.008 = K[.150]^2[.150]$

$K = 2.37 \ \frac{L^2}{mol^2 \cdot s}$

10. Determine the initial rate of B consumption ($\Delta[B]/\Delta t$) for the first trial?
    a) 8.00×10^{-3} mol/L · s
    b) 1.60×10^{-2} mol/L · s
    c) 3.20×10^{-2} mol/L · s
    d) 4.00×10^{-3} mol/L · s
    e) none of these (a-d)

$\frac{\Delta[C]}{\Delta t} = \frac{.008 \text{ mol}}{L \cdot s} \cdot \frac{2 \text{ mol } B}{1 \text{ mol } C} = 0.016 \frac{mol}{L \cdot s} B$

11. Determine the initial rate of C production if [A] = 0.200 M and [B] = 0.500 M ?
    a) 4.74×10^{-2} mol/L · s
    b) 2.37×10^{-1} mol/L · s
    c) 1.19×10^{-1} mol/L · s
    d) 8.23×10^{-2} mol/L · s
    e) none of these (a-d)

$Rate = 2.37[.200]^2[.500]$

$Rate = 0.0474 \frac{mol}{L \cdot s}$

12. What would happen if the kinetic energy of the reactants was not enough to provide the needed activation energy?
    a) The products would be produced at a lower energy state.
    b) The rate of the reaction would tend to increase.
    c) The activated complex would convert into products.
    d) The reactants would re-form.
    e) The products would form at an unstable energy state.

13–16. The following questions refer to the reaction between nitric oxide and hydrogen

$$2NO + H_2 \rightarrow N_2O + H_2O$$

Experiment	Initial [NO] (mol/L)	Initial [H_2] (mol/L)	Initial Rate of Disappearance of NO (mol/L · s)
1	6.4×10^{-3}	2.2×10^{-3}	2.6×10^{-5}
2	12.8×10^{-3}	2.2×10^{-3}	~~1.0×10^{-5}~~ 1.0×10^{-4}
3	6.4×10^{-3}	4.5×10^{-3}	5.1×10^{-5}

13. What is the rate law for this reaction?
    a) Rate = k [NO]
    b) Rate = k [NO]^2
    c) Rate = k [NO]^2 [H_2]
    d) Rate = k [NO] [H_2]
    e) Rate = k [N_2O] [H_2O]

14. What is the magnitude of the rate constant for this reaction?

    a) 1150
    b) 98
    c) 542
    d) 112
    e) 289

$2.6 \times 10^{-5} = k\,[6.4 \times 10^{-3}]^2\,[2.2 \times 10^{-3}]$

$k = 289$

15. What is the order of this reaction?
    a) 0 b) 1 c) 2
    d) 3 e) cannot be determined from the data

16. Which of the following would increase the value of the rate constant for this reaction?
    a) Increasing the concentration of NO
    b) Increasing the concentration of H_2
    c) Increasing the temperature
    d) Measuring the rate over a longer period of time
    e) All of the above

17. Which of the following statements is typically true for a catalyst?
    a) The concentration of the catalyst will go down as a reaction proceeds.
    b) The catalyst provides a new pathway in the reaction mechanism.
    c) The catalyst speeds up the reaction.
    d) Two of these.
    e) None of these.

18–19. The reaction $2NOBr \rightarrow 2NO + Br_2$ exhibits the rate law

$$\text{Rate} = -\frac{\Delta[NOBr]}{\Delta t} = k[NOBr]^2$$ 2nd order where $k = 1.0 \times 10^{-5}$ L/mol · s at 25°C.

This reaction is run where the initial concentration of NOBr is 0.100 M.

18. What is the first half-life for this experiment?
   a) 5.0×10^{-1} s
   b) 6.9×10^{4} s
   c) 1.0×10^{-5} s
   d) 1.0×10^{6} s
   e) none of these

$$\frac{1}{[NOBr]} = kt + \frac{1}{[NOBr]_0}$$

$$\frac{1}{.05} = (1 \times 10^{-5})t + \frac{1}{.100}$$

$$t = 1 \times 10^{6}\ s$$

19. The [NO] after 24.0 hours has passed is
   a) 3.5×10^{-4} M
   b) 9.9×10^{-3} M
   c) 9.2×10^{-2} M
   d) 1.0×10^{-3} M
   e) none of these

24 hr = 86,400 s

$$\frac{1}{[NOBr]} = (1 \times 10^{-5})86{,}400 + \frac{1}{.100}$$

$$\frac{1}{[NOBr]} = 10.86 \qquad [NOBr] = 0.092$$

20-21. For a reaction: $aA \rightarrow$ Products, $[A]_o = 6.0$ M, and the first two half-lives are 56 and 28 minutes, respectively. *Hint: Notice that the time period for each half-life is decreasing*.

20. Calculate k (without units)
   a) 1.2×10^{-2}
   b) 3.0×10^{-3}
   c) 5.4×10^{-2}
   d) 1.0×10^{-2}
   e) none of these

0th order

$$[A] = -kt + [A]_0$$

$$3.0 = -k(56) + 6.0$$

$$k = 0.054\ \frac{mol}{L \cdot min}$$

21. Calculate [A] at t= 99 minutes.
   a) 2.15 M
   b) 1.83 M
   c) 0.95 M
   d) 0.65 M
   e) none of these

$$[A] = -.054(99) + 6.0$$

$$[A] = 0.65\ M$$

22–24. The following questions refer to the reaction $2A_2 + B_2 \rightarrow 2C$. The following mechanism has been proposed:

step 1 (very slow) $A_2 + B_2 \rightarrow R + C$

step 2 (slow) $A_2 + R \rightarrow C$

22. What is the molecularity of step 2?
    a) unimolecular
    b) bimolecular
    c) termolecular
    d) quadmolecular
    e) the molecularity cannot be determined

23. Which step is rate determining?
    a) both steps
    b) step 1 – slowest step
    c) step 2
    d) a step that is intermediate to step 1 and step 2
    e) none of these

24 According to the proposed mechanism, what should the overall rate law be?
    a) rate = $k\,[A_2]^2$
    b) rate = $k\,[A_2]$
    c) rate = $k\,[A_2]\,[B_2]$ – Reactants of slowest step
    d) rate = $k\,[A_2]\,[R]$
    e) rate = $k\,[R]^2$

25. The reaction $2NO + O_2 \rightarrow 2NO_2$ obeys the rate law

$$\text{Rate} = k\,[NO]^2[O_2].$$

Which of the following mechanisms is consistent with the experimental rate law?

a) $NO + NO \rightarrow N_2O_2$ (slow)
   $N_2O_2 + O_2 \rightarrow 2NO_2$ (fast)

b) $NO + O_2 \rightleftharpoons NO_3$ (fast equilibrium)
   $NO_3 + NO \rightarrow 2NO_2$ (slow)

c) $2NO \rightleftharpoons N_2O_2$ (fast equilibrium)
   $N_2O_2 \rightarrow NO_2 + O$ (slow)
   $NO + O \rightarrow NO_2$ (fast)

d) $O_2 + O_2 \rightarrow O_2 + O_2$ (slow)
   $O_2 + NO \rightarrow NO_2 + O$ (fast)
   $O + NO \rightarrow NO_2$ (fast)

e) none of these

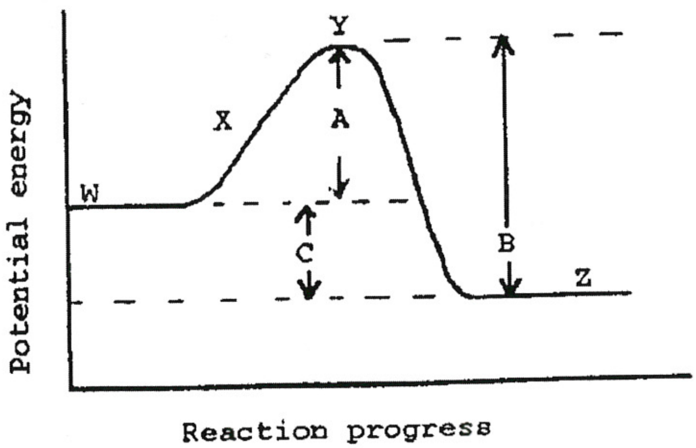
26. The reaction: $2A + B \rightarrow C$ has the following proposed mechanism:

Step 1: $A + B \rightleftharpoons D$ (fast equilibrium)
Step 2: $D + B \rightarrow E$
Step 3: $E + A \rightarrow C + B$

If step 2 is the rate-determining step, then the rate of formation of C should equal:

a) $k\,[A]$
b) $k\,[A]^2\,[B]$
c) $k\,[A]^2\,[B]^2$
d) $k\,[A]\,[B]$
e) $k\,[A]\,[B]^2$

27–29. The questions below refer to the following diagram:



27. Why is this reaction considered to be exothermic?
   a) Because energy difference B is greater than energy difference C
   b) Because energy difference B is greater than energy difference A
   c) Because energy difference A is greater than energy difference C
   d) Because energy difference B is greater than energy difference C plus energy difference A
   e) Because energy difference A and energy difference C are about equal

28. At what point on the graph is the activated complex present?
   a) point W
   b) point X
   c) point Y
   d) point Z
   e) none of these

29. If the reaction were reversible, would the forward or the reverse reaction have a higher activation energy?
   a) The diagram shows no indication of any activation energy.
   b) The forward and reverse activation energies are equal.
   c) The forward activation energy
   d) The reverse activation energy
   e) none of these